PATENT

Docket No. 1232-4046US1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s) :Nozomu Kitagishi

Serial No. :Divisional of 07/865,076

Filed :HEREWITH

For :PLATE-LIKE POLARIZING ELEMENT, A POLARIZING CONVERSION UNIT PROVIDED WITH THE ELEMENT, AND A PROJECTOR PROVIDED WITH THE UNIT

Anticipated Classification of this application:

Class _____ Subclass _____

Prior Application

Examiner: R. Shafer

Group Art Unit:2507

FILING UNDER 37 C.F.R. § 1.60

ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20231

Sir:

1. [ X ] This is a request for filing a [ ] Continuation [ X] Divisional application under 37 C.F.R. § 1.60, of pending parent application Serial No. 07/865,076 of Nozomu Kitagishi (list each inventor) filed on April 8, 1992.

2. [ X ] The attached papers are a true copy of the above-identified parent application as filed, including the oath or declaration originally filed (37 C.F.R. § 1.60), and no amendments referred to in the oath or declaration filed to complete the parent application introduced new matter therein.

3. [ X ] The copy of the papers of the parent application as filed which are attached are as follows:

[ X ] 53 page(s) of specification

[ X ] 19 page(s) of claims

[ X ] 1 page(s) of abstract

[ X ] 14 page(s) of drawing

[ X ] 5 page(s) of declaration and power of attorney

[ X ] in accordance with 37 C.F.R. § 1.60(b), our records reflect that the original signed declaration showing applicant's signature was filed on April 8, 1992 in application Serial No. 07/865,076.

[ ] _____ page(s) of Sequence Listing

[ ] _____ computer disk(s) containing Sequence Listing

[ ] _____ computer disk containing original Sequence Listing previously submitted with application Serial No. _____, filed _____.

[ ] Statement under 37 C.F.R. § 1.821(f) that computer and paper copies of the Sequence Listing are the same.

[ ] Other _____.

4. [ X ] Cancel in this application original claims 1-20, 24-35 of the parent application before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)

5. [ ] A Preliminary Amendment is enclosed. (Claims added by this Amendment have been properly numbered consecutively beginning with the number next following the highest numbered original claim in the prior application.)

CLAIMS FOR FEE CALCULATION

| | Number | | Number Extra | Rate for Non-Small Entity | Basic Fee $770.00 |
|---|---|---|---|---|---|
| Total* Claims | 3 | -20 | | x $22.00 | $ |
| Independent Claims | 3 | - 3 | | x $80.00 | $ |
| Multiple Dependent Claim(s) | | [ ] yes | Addt'l Fee | $260.00 | |
| | | [ X ] no | None | ---- | $ |

Filing Fee Calculation $ 770.00

6. [ ] A verified statement that this filing is by a small entity is attached or has been filed in the parent application and its benefit under 37 C.F.R. § 1.28(a) is hereby claimed. Reduced fees under 37 C.F.R. § 1.9(f) (50% of total) paid herewith $ _____.

7. [ X ] The status of the parent application is as follows:

[ ] A Petition For Extension of Time, and Fee therefor has been or is being filed in the parent application to extend the term for action in the parent application until _____.

[ ] A copy of the Petition for Extension of Time in the copending parent application is attached.

[ X ] No Petition For Extension of Time and Fee therefor are necessary in the copending parent application.

* Includes all independent and single dependent claims and all claims referred to in multiple dependent claims. See 37 C.F.R. § 1.75(c).

8. [ ] Please abandon the parent application at a time while the parent application is pending or at a time when the petition for extension of time in that application is granted and while this application is pending and has been granted a filing date, so as to make this application copending with said parent application. ATTACHED IS AN EXPRESS ABANDONMENT FOR FILING IN THE PARENT APPLICATION FILE.

9. [ ] Transfer the drawing(s) from the parent application to this application.

10. [ ] New drawings are enclosed: [ ] formal [ ] informal

11. [X ] Priority of application Serial No. 3-103317, filed on April 9, 1991 in Japan is claimed under 35 U.S.C. § 119.

a. [ ] The certified copy is on file

[ X ] in the above-identified parent application.

[ ] application Serial No. _____.

b. [ ] The certified copy will follow.

c. [ ] The certified copy is enclosed herewith.

d. [ ] The certified English translation

[ ] is enclosed

[ ] is on file in application Serial No. _____.

12. [ X ] Amend the specification by inserting before the first line the sentence:

This is a [ ] continuation [X] divisional of co-pending application Serial No. 07/865,076 filed April 8, 1992.

13. a. [ ] With respect to the inventorship of the copending parent application from which this application claims benefit under 35 U.S.C. § 120, the inventor(s) in this application is (are) less than those named in the copending parent application and the following inventor(s) should be deleted from this application:

_____.

A Petition requesting correction of inventorship for this application in accordance with 37 C.F.R. §§1.48 and 1.60(b) is enclosed.

b. [ ] In view of the granting of the Petition requesting correction of inventorship in (parent) application Serial No. _____, filed _____, this application is being filed in the name of the corrected inventive entity.

14. [ X ] The parent application is assigned of record to Canon Kabushiki Kaisha, recorded on April 8, 1992, Reel 6081, Frame 0840.

15. [ ] A check in the amount of $_____ to cover the filing fee is attached.

16. [ X ] Charge fee to Deposit Account No. 13-4500. Order No. 1232-4046US1. A DUPLICATE COPY OF THIS SHEET IS ATTACHED.

17. [ X ] The Assistant Commissioner is hereby authorized to charge any additional fees which may be required for filing this application, or credit any overpayment to Deposit Account No. 13-4500. Order No. 1232-4046US1. A DUPLICATE COPY OF THIS SHEET IS ATTACHED.

18. [ X ] The power of attorney in the parent application is to:

Jerome G. Lee, (Reg. No. 16,967) et al.

a. [ X] The power was filed in the parent application and a copy is enclosed.

b. [ ] A new power has been executed and is attached.

c. [ ] Address all future communications to:

MORGAN & FINNEGAN, L.L.P.
345 Park Avenue
New York, New York 10154

Respectfully submitted,

MORGAN & FINNEGAN, L.L.P.

Dated: September 24, 1997

By: _____
David V. Rossi
Registration No. 36,659

Mailing Address:

MORGAN & FINNEGAN, L.L.P.
345 Park Avenue
New York, New York 10154
(212) 758-4800
(212) 751-6849 Telecopier

FORM: RULE-60.NY
Rev. 10/1/96

Docket No. 1232-4046US1

14. [ X ] The parent application is assigned of record to Canon Kabushiki Kaisha, recorded on April 8, 1992, Reel 6081, Frame 0840.

15. [ ] A check in the amount of $_____ to cover the filing fee is attached.

16. [ X ] Charge fee to Deposit Account No. 13-4500. Order No. 1232-4046US1. A DUPLICATE COPY OF THIS SHEET IS ATTACHED.

17. [ X ] The Assistant Commissioner is hereby authorized to charge any additional fees which may be required for filing this application, or credit any overpayment to Deposit Account No. 13-4500. Order No. 1232-4046US1. A DUPLICATE COPY OF THIS SHEET IS ATTACHED.

18. [ X ] The power of attorney in the parent application is to:

Jerome G. Lee, (Reg. No. 16,967) et al.

a. [ X] The power was filed in the parent application and a copy is enclosed.

b. [ ] A new power has been executed and is attached.

c. [ ] Address all future communications to:

MORGAN & FINNEGAN, L.L.P.
345 Park Avenue
New York, New York 10154

Respectfully submitted,

MORGAN & FINNEGAN, L.L.P.

Dated: September 24, 1997

By: _____
David V. Rossi
Registration No. 36,659

Mailing Address:

MORGAN & FINNEGAN, L.L.P.
345 Park Avenue
New York, New York 10154
(212) 758-4800
(212) 751-6849 Telecopier

FORM: RULE-60.NY
Rev. 10/1/96

Docket No. 1232-4046US1

14. [ X ] The parent application is assigned of record to Canon Kabushiki Kaisha, recorded on April 8, 1992, Reel 6081, Frame 0840.

15. [ ] A check in the amount of $_____ to cover the filing fee is attached.

16. [ X ] Charge fee to Deposit Account No. 13-4500. Order No. 1232-4046US1. A DUPLICATE COPY OF THIS SHEET IS ATTACHED.

17. [ X ] The Assistant Commissioner is hereby authorized to charge any additional fees which may be required for filing this application, or credit any overpayment to Deposit Account No. 13-4500. Order No. 1232-4046US1. A DUPLICATE COPY OF THIS SHEET IS ATTACHED.

18. [ X ] The power of attorney in the parent application is to:

Jerome G. Lee, (Reg. No. 16,967) et al.

a. [ X] The power was filed in the parent application and a copy is enclosed.

b. [ ] A new power has been executed and is attached.

c. [ ] Address all future communications to:

MORGAN & FINNEGAN, L.L.P.
345 Park Avenue
New York, New York 10154

Respectfully submitted,

MORGAN & FINNEGAN, L.L.P.

Dated: September 24, 1997

By: _____
David V. Rossi
Registration No. 36,659

Mailing Address:

MORGAN & FINNEGAN, L.L.P.
345 Park Avenue
New York, New York 10154
(212) 758-4800
(212) 751-6849 Telecopier

FORM: RULE-60.NY
Rev. 10/1/96

# A Plate-like Polarizing Element, a Polarizing Conversion Unit Provided with the Element, and a Projector Provided with the Unit

## BACKGROUND OF THE INVENTION

### Field of the Invention

This invention relates to a polarizing element from which incident light having random polarization direction components emerges with the polarization direction uniformized, and a projector using such polarizing element.

### Related Background Art

There is known a projector of the construction as shown in Figure 1 of the accompanying drawings.

A light beam emitted from a light source 1550 is separated into red, green and blue lights by dichroic mirrors 1551 and 1552, and the red, green and blue lights are directed to liquid crystal light bulbs 1554, 1555 and 1556, respectively, by the use of a total reflection mirror 1553 and further, the optical paths of these lights are bent by a total reflection mirror 1557, and the three red, green and blue images are combined by dichroic mirrors 1558 and 1559 and the combined image is projected onto a screen, not shown, by a projection lens 1560.

Such a projector adopts a construction in which the liquid crystal light bulbs 1554, 1555 and 1556 assume a form in which a liquid crystal plate is interposed between two polarizing plates which are polarizing elements and when natural light having random polarization directions enters the incidence side polarizing plate, polarized lights in the other polarization directions than one polarization direction are absorbed by said incidence side polarizing plate and only the light in one polarization direction enters the liquid crystal plate.

On the other hand, the projector described in Japanese Patent Laid-Open Application No. 61-90584 adopts a construction in which the incidence side polarizing plate is eliminated and instead, by the use of a prism and a beam splitter which is a polarizing element, light is caused to enter a liquid crystal plate with the polarization directions thereof uniformized in one direction.

However, the projector shown in Figure 1 suffers from the problem that lights in the other polarization directions than the polarization direction of the polarized light transmitted through the incidence side polarizing plate are absorbed by the incidence side polarizing plate and therefore the projection image field becomes dark, and further

suffers from the problem that the temperature of the liquid crystal plate is increased by the absorbed lights, thus resulting in the deterioration of the liquid crystal plate.

On the other hand, in the projector described in Japanese Patent Laid-Open Application No. 61-90584, the use of the polarizing beam splitter and the prism leads to the bulkiness of the apparatus and moreover, there is the problem that labor and cost are required for the polarizing of the prism. Also, the use of a glass block such as a prism leads to too great a weight, which in turn leads to bad portability as a projector.

## SUMMARY OF THE INVENTION

It is the object of the present invention to realize a polarizing element which can efficiently use incident light and can realize a low-cost and compact projector.

The polarizing element of the present invention is provided on one surface of a transparent plane parallel plate with polarizing separating film for dividing incident light entering the plane parallel plate from said one surface or the other surface side into reflected light and transmitted light, and reflects one of said reflected light and said transmitted light by a reflecting surface

provided on said other surface of said transparent plane parallel light and directs it to an optical path substantially parallel to the optical path of the other light, and varies the polarized state of at least one of said reflected light and said transmitted light to thereby make the polarized states of the two lights coincident with each other.

Also, the polarizing conversion unit of the present invention is provided with an illuminating system for supplying non-polarized light having polarized components in lattice-like random directions, and a polarizing element provided obliquely with respect to the optical axis of said illuminating system to convert said non-polarized light into substantially dense polarized light, said polarizing element having a transparent plane parallel plate provided with polarizing separating film on one surface thereof, one of lattice-like reflected light and lattice-like transmitted light created by said polarizing separating film being reflected by a reflecting surface provided on the other surface of the transparent plane parallel plate and being directed to an optical path substantially parallel to the optical path of the other light, the polarized state of at least one of said lattice-like reflected light and said lattice-like transmitted light being varied to thereby make the polarized

states of the two lights coincident with each other.

Also, the projector of the present invention is a projector provided with a light source emitting non-polarized light, an illuminating optical system for converting the non-polarized light from said light source into polarized light, an image generator for modulating said polarized light in conformity with a video signal to thereby generate an image, and a projecting optical system for projecting said image, said illuminating optical system having a converting system for converting said non-polarized light into a lattice-like light pattern, and a polarizing element provided obliquely with respect to the optical axis of said converting system to convert said lattice-like light pattern into substantially dense polarized light, said polarizing element having a transparent plane parallel plate provided with polarizing separating film on one surface thereof, one of lattice-like reflected light and lattice-like transmitted light created by said polarizing separating film being reflected by a reflecting surface provided on the other surface of the transparent plane parallel plate and being directed to an optical path substantially parallel to the optical path of the other light, the polarized state of at least one of said lattice-like reflected light and said lattice-like transmitted light being

varied to thereby make the polarized states of the two lights coincident with each other.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows the construction of a projector according to the prior art.

Figure 2 shows the construction of a first embodiment of the present invention.

Figure 3 shows the construction of a projector according to the first embodiment of the present invention.

Figure 4 shows the construction of a second embodiment of the present invention.

Figure 5 shows the construction of a third embodiment of the present invention.

Figure 6 shows the construction of a fourth embodiment of the present invention.

Figure 7 shows the construction of a fifth embodiment of the present invention.

Figure 8 shows the construction of a sixth embodiment of the present invention.

Figure 9 shows the construction of a seventh embodiment of the present invention.

Figure 10 shows the construction of an eighth embodiment of the present invention.

Figure 11 shows the construction of a ninth embodiment of the present invention.

Figure 12 shows the construction of a tenth embodiment of the present invention.

Figure 13 shows the construction of an eleventh embodiment of the present invention.

Figure 14 shows the construction of a twelfth embodiment of the present invention.

Figure 15 shows the construction of a thirteenth embodiment of the present invention.

Figure 16 shows the construction of a fourteenth embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 2 shows the construction of a first embodiment of the present invention.

The present embodiment is comprised of a condensing lens 101 which is a resin molded article comprising cylindrical minute lenses $101_1$, $101_2$ and $101_3$ and which is an illuminating system emitting incident light as lattice-like non-polarized light, and a plane parallel plate 103 of a transparent optical material provided at an angle of 45° with respect to the optical axis of the condensing lens 101. The incidence side surface and the emergence side surface of each of the cylindrical minute lenses $101_1$, $101_2$ and $101_3$ have positive power and negative power, respectively, and the negative power has magnitude twice as great as the positive power, and

each of the cylindrical minute lenses has the function of an afocal converter from which the incident light which is parallel light emerges as parallel light having 1/2 of the width thereof.

On that side of the plane parallel plate 103 which is adjacent to the condensing lens 101, pairs of polarizing separating film 104 formed of multilayer film of a dielectric material or the like and film-like half wavelength plates (half wavelength film) 106 are provided in a stripe-like pattern at the pitch of the cylindrical minute lenses $101_1$ - $101_3$ as viewed from the direction of 45° and so that the width of each of them may be substantially equal to the width of the light beam condensed by the cylindrical minute lens $101_1$ - $101_3$. On the whole of that surface of the plane parallel plate 103 which is opposite to the condensing lens 101, there is provided aluminum total reflection film 105 subjected to high reflection treatment.

Assuming that the light beam 102 incident on the condensing lens 101 is substantially parallel light, this light beam 102 is compressed into lattice-like substantially parallel light of a half width by the cylindrical minute lenses $101_1$ - $101_3$ of the condensing lens 101, and is separated as follows by the polarizing separating film 104 provided on that surface of the plane parallel plate 103 which

is adjacent to the condensing lens 101.

S-polarized light 102S is reflected in a direction orthogonal to the incident light, and P-polarized light 102P is transmitted. The transmitted P-polarized light 102P is reflected by the aluminum total reflection film 105 provided on that surface of the plane parallel plate 103 which is opposite to the incidence side, whereafter it passes through the half wavelength plate 106, whereby the polarization direction thereof is rotated by 90° and this light emerges as S-polarized light. The incident natural light is uniformized into S-polarized lights in this manner. Alternatively, the aluminum total reflection film 105 may not be formed and that surface of the plane parallel plate 103 which is opposite to the incidence side may be set as a total reflection surface, and P-polarized light may be reflected by this surface.

Figure 3 shows the construction of a projector which incorporates therein the polarizing element constructed as described above.

A parallel light beam having various polarization directions which is emitted from a light source 250 is converted into only S-polarized light by the polarizing element shown in Figure 2 and emerges.

Dichroic mirrors 251, 252, 258, 259, total

reflection mirrors 253, 257, liquid crystal light bulbs 254, 255, 256 and a projection lens 260 in the present embodiment are similar in construction to the dichroic mirrors 1551, 1552, 1558, 1559, the total reflection mirrors 1553, 1557, the liquid crystal light bulbs 1554, 1555, 1556 and the projection lens 1560, respectively, shown in Figure 1.

The liquid crystal light bulbs 254, 255 and 256 each modulate the orientation of a plurality of liquid crystal elements contained therein inconformity with a video signal input thereto from an image generator (not shown) comprised of three generators for generating red, green and blue images, respectively, whereby images are generated. The dichroic mirrors 251, 252, 258 and 259 together constitute a color resolving system for resolving the illuminating light converted into only S-polarized light by the polarizing element shown in Figure 2 into red, green and blue lights.

By the above-described construction, the loss of light in each of the liquid crystal light bulbs 254, 255 and 256 is eliminated and therefore, the projected image can be made bright and the generation of heat by the absorption of light does not occur. In this case, polarizing plates need not be provided on the incidence side of the liquid crystal light bulbs, but they may be provided to

increase the purity of polarized light.

If design is made such that the incidence surface of the polarizing element is perpendicular to the plane of the drawing sheet and the light source 250 is disposed in a direction perpendicular to the plane of the drawing sheet, P-polarized light can be caused to be incident on each dichroic mirror and therefore, color resolution-combination can be accomplished efficiently.

Figure 4 shows the construction of a second embodiment of the present invention.

In the present embodiment, polarizing separating film 304 formed of multilayer film is provided on the whole of that surface of a plane parallel plate 103 provided at an angle of 45° with respect to the optical axis of a condensing lens 101 which is adjacent to the condensing lens, and film-like half wavelength plates 306 are provided on the polarizing separating film at the pitch of cylindrical minute lenses $101_1$ - $101_3$ as viewed from the direction of 45° and so that the width each of them may be substantially equal to the width of the light beam condensed by each cylindrical minute lens. In the other points, the construction of the present embodiment is similar to that of the first embodiment shown in Figure 2 and therefore, similar elements are given similar reference numerals and need not be

described.

With the construction as described above, it is not necessary to effect masking when the polarizing separating film is deposited by evaporation and thus, the manufacturing process can be further simplified.

Figure 5 shows the construction of a third embodiment of the present invention.

The present embodiment is such that in the second embodiment, film-like half wavelength plate 406 directly formed on the polarizing separating film 304 is formed on a holding plane parallel plate 409 and this holding plane parallel plate 409 is joined to the plane parallel plate 103 through the polarizing separating film 304. Also, the aluminum total reflection films 305 provided on the whole of that surface which is opposite to the condensing lens 101 are provided as aluminum total reflection films 405 provided at substantially the pitch of the cylindrical minute lenses $101_1$ - $101_3$ as viewed from the direction of 45° and with the width of each of them substantially equal to the width of the light beam condensed by each cylindrical minute lens so that stray light may not be reflected in the direction of emergence of regular light, and further, absorbent paint 411 covering the whole of that surface of the plane parallel plate 103 which is

opposite to the condensing lens 101 is provided to thereby achieve the effect of cutting stray light. Also, a half wavelength plate 406 may be formed in a lattice-like pattern on the plane parallel plate 103 and polarizing separating film 304 may be formed in a lattice-like pattern on the holding plane parallel plate 409 so that their phases may be inverted with respect to each other, and they may be joined together. Also, both of the half wavelength plate 406 and the polarizing separating film 304 may be formed on the holding plane parallel plate 409, and the plane parallel plate 103 and the holding plane parallel plate 409 may be cemented together.

Figure 6 shows the construction of a fourth embodiment of the present invention.

The present embodiment is one in which polarizing rotational means is provided on the whole surface of the plane parallel plate 103. In the present embodiment, on that surface of the plane parallel plate 103 provided at an angle of 45° with respect to the optical axis of the condensing lens 101 which is adjacent to the condensing lens 101, polarizing separating films 504 formed of multilayer films are provided at the pitch of the cylindrical minute lenses $101_1$ - $101_3$ as viewed from the direction of 45° and with substantially the same width as the width of the light beam condensed by

each cylindrical minute lens. On the other hand, on the whole of that surface of the plane parallel plate 103 which is opposite to the condensing lens 101, a film-like quarter wavelength plate 506 is provided and further, a holding plane parallel plate 510 having aluminum total reflection film 505 deposited by evaporation on the whole surface thereof is provided so that the aluminum total reflection film 505 and the quarter wavelength plate 506 may be opposed to each other.

With the construction as described above, the film-like quarter wavelength plate 506 can be attached to the whole of that surface of the plane parallel plate 103 which is opposite to the condensing lens 101 and therefore, the manufacturing process can be simplified.

Assuming that the light beam 102 entering the polarizing conversion element is a substantially parallel light beam, the width of the light beam is compressed by the cylindrical minute lenses $101_1$ - $101_3$ constituting the condensing lens 101, and S-polarized light 102S is reflected by the polarizing separating film 504 provided on that surface of the plane parallel plate 103 which is adjacent to the condensing lens 101 and P-polarized light 102P is transmitted through the polarizing separating film 504. The transmitted P-polarized light 102P passes

through the quarter wavelength plate 506 provided on that surface of the plane parallel plate 103 which is opposite to the condensing lens 101, whereby it becomes circularly polarized light and is reflected by the aluminum total reflection film 505, whereafter it passes through the quarter wavelength plate 506 again, whereby it becomes S-polarized light whose polarizing direction has been rotated by 90° and emerges from among the polarizing separating films 504.

The incident natural light can be uniformized into S-polarized light in the manner described above.

Figure 7 shows a fifth embodiment of the present invention.

The present embodiment, like the fourth embodiment shown in Figure 6, is one in which polarizing rotational means is provided on the whole surface of the plane parallel plate 103.

In the present embodiment, a film-like quarter wavelength plate 606 is provided on the whole of that surface of the plane parallel plate 103 provided at an angle of 45° with respect to the optical axis of the condensing lens 101 which is adjacent to the condensing lens 101. On the quarter wavelength plate 606, polarizing separating films 604 are provided at the pitch of the cylindrical minute lenses $101_1$ - $101_3$ as viewed from the direction of

45° and with substantially the same width as the width of the light beam condensed by each cylindrical minute lens, and on the other hand, aluminum total reflection film 605 is deposited by evaporation on that surface of the plane parallel plate 103 which is opposite to the condensing lens 101.

As described above, the film-like quarter wavelength plate 606 is attached to the whole of that surface of the plane parallel plate 103 which is adjacent to the condensing lens 101, whereby the manufacturing process can be simplified.

The light beam 102 entering the polarizing elemnt has its beam width compressed by the cylindrical minute lenses $101_1$ - $101_3$ constituting the condensing lens 101, and S-polarized light 102S is reflected in a direction orthogonal to the incident light by the polarizing separating films 604 provided on that surface of the plane parallel plate 103 which is adjacent to the condensing lens 101, and P-polarized light 102P is transmitted through the polarizing separating films 604. The transmitted P-polarized light 102P passes through the quarter wavelength plate 606, whereby it becomes circularly polarized light and is reflected by the aluminum total reflection film 605 provided on that surface of the plane parallel plate 103 which is opposite to the condensing lens 101, whereafter it passes through

the quarter wavelength plate 606 again, whereby it becomes S-polarized light whose polarization direction has been rotated by 90° and emerges from among the polarizing separating films 604.

The incident natural light can be uniformized into S-polarized light in the manner described above.

In the present embodiment, in order that the illuminating light which has deviated from the parallel light may not become stray light, a light intercepting plate 612 which intercepts the illuminating light which has deviated from the parallel light and passes the emergent light therethrough is provided on that portion of the plane parallel plate 103 which is adjacent to the condensing lens 101 substantially in parallelism to the emergent light to thereby improve the purity of the polarization of the emergent light.

Figure 8 shows the construction of a sixth embodiment of the present invention.

The present embodiment is one in which minute prisms are combined with a plane parallel plate.

On that surface of the plane parallel plate 103 provided at an angle of 45° with respect to the optical axis of the condensing lens 101 which is adjacent to the condensing lens 101, pairs of polarizing separating films 704 formed by multilayer film and half wavelength plates 706 are provided at

the pitch of the cylindrical minute lenses $101_1$ - $101_3$ as viewed from the direction of 45° and with substantially the same width as the width of the light beam condensed by each cylindrical minute lens, and aluminum total reflection film 705 is provided on the whole of that surface of the plane parallel plate 103 which is opposite to the condensing lens 101. Further, on that surface of the plane parallel plate 103 which is adjacent to the condensing lens 101, a prism plate 708 comprising minute prisms $708_1$ - $708_5$ each having a flat surface substantially perpendicular to the optical axis of the condensing lens 101 and a flat surface substantially perpendicular to the emergent light is provided in contact with the plane parallel plate 103.

Assuming that the light beam 102 entering the polarizing element is a substantially parallel light beam, the width of the light beam is compressed by the cylindrical minute lenses $101_1$ - $101_3$ constituting the condensing lens 101, and the light beam enters the minute prisms $708_1$ - $708_5$ constituting the prism plate 708 and is separated into S-polarized light 102S and P-polarized light 102P by the polarizing separating film 704 provided on that surface of the plane parallel plate 103 which is adjacent to the condensing lens 101. The S-polarized light 102S is reflected in a direction

orthogonal to the incident light 102 and emerges through the minute prisms $708_1$, $708_3$ and $708_5$ constituting the prism plate 708. The P-polarized light 102P is transmitted through the polarizing separating films 704, is reflected by the aluminum total reflection film 705 provided on that surface of the plane parallel plate 103 which is opposite to the condensing lens 101, and passes through the half wavelength plates 706, whereby it becomes S-polarized light whose polarization direction has been rotated by 90°, and emerges through the minute prisms $708_2$ and $708_4$ constituting the prism plate 708.

The incident natural light can be uniformized into S-polarized light in the manner described above.

If as in the present embodiment, the polarizing separating films are provided in the optical medium, the extinction ratio can be enhanced over a wide band.

Figure 9 shows the construction of a seventh embodiment of the present invention.

The present embodiment, like the sixth embodiment shown in Figure 8, is one in which minute prisms are combined with a plane parallel plate.

Polarizing separating film 804 formed of multilayer film is provided on the whole of that surface of the plane parallel plate 103 provided at an angle of 45° with respect to the optical axis of

the condensing lens 101 which is adjacent to the condensing lens 101, and aluminum total reflection film 805 is provided on the whole of that surface of the plane parallel plate 103 which is opposite to the condensing lens 101. Further, on that surface of the plane parallel plate 103 which is adjacent to the condensing lens 101, a prism plate 808 comprising minute prisms $808_1$ - $808_5$ each having a flat surface substantially perpendicular to the optical axis of the condensing lens 101 and a flat surface substantially perpendicular to the emergent light is provided in contact with the plane parallel plate 103.

A film-like half wavelength plate 806 is provided on each of the exit portions of those $808_2$ and $808_4$ of the minute prisms $808_1$ - $808_5$ constituting the prism plate 808 which are located among the cylindrical minute lenses, and light intercepting members 812 are provided on the surfaces perpendicular to the exit portions.

By the construction as described above, as in the sixth embodiment shown in Figure 8, the incident natural light can be uniformized into S-polarized light and further, by the provision of the light intercepting members 812, stray light can be eliminated and the extinction ratio can be made high.

Figure 10 shows the construction of an eighth

embodiment of the present invention which is applied to a transmission type polarizing element.

The polarizing element of the present embodiment is comprised of a condensing lens 901 which is a resin molded article comprised of cylindrical minute lenses $901_1$ - $901_3$ having the function of an afocal converter, and a plane parallel plate 903 disposed so that the planar portion thereof may have an angle of 45° with respect to the optical axis of the condensing lens 901. On that surface of the plane parallel plate 903 which is opposite to the condensing lens 901, pairs of polarizing separating films 904 formed of multiplayer film and film-like half wavelength plates 906 are provided at the pitch of the cylindrical minute lenses $901_1$ - $901_3$ as viewed from the direction of 45° and with substantially the same width as the width of the light beam condensed by each cylindrical minute lens, and on that surface of the plane parallel plate 903 which is adjacent to the condensing lens 901, aluminum total reflection films 905 are provided at the pitch of the cylindrical minute lenses $901_1$ - $901_3$ as viewed from the direction of 45° and so that the width of each of them may be substantially the same as the width of the light beam condensed by each cylindrical minute lens.

Assuming that the light beam 902 entering

the polarizing element is a substantially parallel light beam, the light beam 902 has its beam width compressed by the cylindrical minute lenses $901_1$ - $901_3$ constituting the condensing lens 901, and passes through among the aluminum total reflection films 905 provided on that surface of the plane parallel plate 903 which is adjacent to the condensing lens 901, and enters the polarizing separating films 904 provided on that surface of the plane parallel plate 903 which is opposite to the condensing lens 901. The light beam 902 which has entered the polarizing separating films 904 is separated into P-polarized light 902P and S-polarized light 902S. The P-polarized light 902P is transmitted through the polarizing separating films 904 and emerges therefrom. On the other hand, the S-polarized light 902S is reflected, and is further reflected by the aluminum total reflection films 905 provided on that surface of the plane parallel plate 903 which is adjacent to the condensing lens 901, and emerges condensing lens 901, and emerges through the half wavelength plates 906 provided on that surface of the plane parallel plate 903 which is opposite to the condensing lens 901. By passing through the half wavelength plates 906, the S-polarized light has its polarization direction rotated by 90° and emerges as P-polarized light.

The incident natural light can be uniformized into P-polarized in the manner described above.

Figure 11 shows the construction of a ninth embodiment of the present invention which, like the eighth embodiment shown in Figure 10, is applied to a transmission type polarizing element.

In the present embodiment, on that surface of the plane parallel plate 903 which is opposite to the condensing lens 901, film-like half wavelength plates 1006 are provided at the pitch of the cylindrical minute lenses $901_1$ - $901_3$ as viewed from the direction of 45° and so that the width of each of them may be substantially the same as the width of the light beam condensed by each cylindrical minute lens, and polarizing separating film 1004 formed of multilayer film is provided fully thereon. On the other hand, on that surface of the plane parallel plate 903 which is adjacent to the condensing lens 901, aluminum (or silver) total reflection films 1005 are provided at the pitch of the cylindrical minute lenses $901_1$ - $901_3$ as viewed from the direction of 45° and so that the width of each of them may be substantially the same as the width of the light beam condensed by each cylindrical lens. In the other points, the construction of the present embodiment is similar to that of the eighth embodiment shown in Figure 10 and therefore, similar elements are given

similar reference numerals and need not be described.

By the construction as described above, the incident natural light can be uniformized into P-polarized light as in the eighth embodiment shown in Figure 10. Also, in the present embodiment, the polarizing separating film is provided on the whole surface and therefore, it is not necessary to effect masking when it is formed and thus, the manufacturing process can be simplified.

Figure 12 shows the construction of a tenth embodiment of the present invention which, like the eighth and ninth embodiments shown in Figures 10 and 11, is applied to a transmission type polarizing element.

In the present embodiment, on that surface of the plane parallel plate 903 which is opposite to the condensing lens 901, polarizing separating films 1104 are provided at the pitch of the cylindrical minute lenses $901_1$ - $901_3$ as viewed from the direction of 45° and so that the width of each of them may be substantially the same as the width of the light beam condensed by each cylindrical minute lens, and on the other hand, on that surface of the plane parallel plate 903 which is adjacent to the condensing lens 901, a film-like quarter wavelength plate 1106 is provided, and further on the quarter wavelength plate 1106, aluminum (or silver) total

reflection films 1105 are provided at the pitch of the cylindrical minute lenses $901_1$ - $901_3$ as viewed from the direction of 45° and so that the width of each of them may be substantially the same as the width of the light beam condensed by each cylindrical minute lens. Also, absorbing members 1116 for absorbing and eliminating any unnecessary light are provided on both sides of each polarizing separating film 1104 on that surface of the plane parallel plate which is opposite to the condensing lens 901. In the other points, the construction of the present embodiment is similar to the construction of the eighth and ninth embodiments shown in Figures 10 and 11 and therefore, similar elements are given similar reference numerals and need not be described.

Figure 13 shows the construction of an eleventh embodiment of the present invention.

In the present embodiment, a condensing lens 1301 is comprised of cylindrical minute lenses $1301_1$ - $1301_3$, and the plane parallel plate 903 is provided at an angle of 45° with respect to the optical axis of the condensing lens 1301. Half wavelength plates 1306 are provided at predetermined locations on that surface of the plane parallel plate 903 which is opposite to the condensing lens 1301, and polarizing separating film 1304 formed of multilayer film is further provided on the whole of said surface.

Aluminum total reflection films 1305 subjected to high reflection treatment are provided on that surface of the plane parallel plate 903 which is adjacent to the condensing lens 1301. The half wavelength plates 1306 and the aluminum total reflection films 1305 are provided at the pitch of the cylindrical minute lenses $1301_1$ - $1301_3$ as viewed from the direction of 45° and so that the width of each of them may be substantially the same as the width of the light beam condensed by each cylindrical minute lens. An emergence side prism plate 1307 and an incidence side prism plate 1308 covering the whole surface of the plane parallel plate 903 are provided on top of the polarizing separating film 1304 and aluminum total reflection films 1305, respectively. The emergence side prism plate 1307 is comprised of minute prisms $1307_1$ - $1307_5$, and the incidence side prism plate 1308 is comprised of minute prisms $1308_1$ - $1308_3$. Each of these minute prisms $1307_1$ - $1307_5$ and $1308_1$ - $1308_3$ has a flat surface parallel to a flat surface (exit portion) perpendicular to the optical axis of the condensing lens 1301, and two of the minute prisms constituting the emergence side prism plate 1307 are provided for each cylindrical minute lens, and one of the minute prisms constituting the incidence side prism plate 1308 is provided for each cylindrical minute lens. The

cylindrical minute lenses $1301_1$ - $1301_3$ constituting the condensing lens 1301 are disposed with level differences to prevent any light deviating from the parallel light beam from becoming lost light, and are constructed so as to be proximate to the corresponding minute prisms $1308_1$ - $1308_3$.

Assuming that the light beam 902 entering the polarizing element constructed as described above is a parallel light beam, the light beam 902 is compressed to a half width by the cylindrical minute lenses $1301_1$ - $1301_3$ constituting the condensing lens 1301, enters the minute prisms $1308_1$ - $1308_3$ constituting the incidence side prism plate 1308, and passes through the gaps among the aluminum total reflection films 1305 provided on that surface of the plane parallel plate 903 which is adjacent to the condensing lens 1301, whereafter it is separated into P-polarized light 902P and S-polarized light 902S by the polarizing separating film 1304 provided on that surface of the plane parallel plate 903 which is opposite to the condensing lens 1301. The P-polarized light 902P is transmitted through the polarizing separating film 1304 and emerges through the minute prisms $1307_1$ and $1307_3$ constituting the emergence side prism plate 1307. On the other hand, the S-polarized light 902S is reflected in a direction orthogonal to the incident light, and

is reflected by the aluminum total reflection films 1305 provided on that surface of the plane parallel plate 903 which is adjacent to the condensing lens 1301, whereafter it emerges through the half wavelength plates 1306, the polarizing separating film 1304 and the minute prisms $1307_2$ and $1307_4$ constituting the emergence side prism plate 1307. The S-polarized light, when it passes through the half wavelength plates 1306, has its polarization direction rotated by 90° and becomes P-polarized light, and because it further passes through the polarizing separating film 1304, all the emergent light becomes P-polarized light of high purity.

The incident natural light can be uniformized into P-polarized light in the manner described above.

By adopting a construction like that of the present embodiment wherein the polarizing separating film in the optical medium, the extinction ratio can be made high over a wide band.

Figure 14 shows the construction of a twelfth embodiment of the present invention.

The present embodiment is one in which use is made of conversion units $1401_1$ - $1401_3$ similar in construction to the embodiment shown in Figure 13 and the end portions of these units are uniformized and installed parallel to one another to thereby save the space.

By adopting such a construction, the volume occupied by the polarizing conversion element, particularly the dimensions of the condensing lens in the direction of the optical axis thereof, can be made small. For example, by the polarizing conversion element being divided into three units as shown, the dimensions of the condensing lens in the direction of the optical axis thereof can be reduced to about 1/3, and this can contribute to the compactness of the projector constructed by the use of it.

Figure 15 shows a thirteenth embodiment of the present invention.

The difference of this embodiment from the embodiment of Figure 11 is that in the embodiment of Figure 11, the half wavelength plates are intermittently provided, whereas in the present embodiment, a quarter wavelength plate is provided on substantially the whole of that surface of the plane parallel plate 903 which is opposite to the condensing lens 901. In the other points, the present embodiment is similar to the embodiment of Figure 1.

Of the light beam 902 having had its beam width compressed by the condensing lens 901, P-polarized light 902P is transmitted through polarizing separating film 1004 provided on that

surface of the plane parallel plate 903 which is opposite to the condensing lens 901 and S-polarized light is reflected by the polarizing separating film 104. The S-polarized light passes through a quarter wavelength plate 506 provided on that surface of the plane parallel plate 903 which is opposite to the condensing lens 901, whereby it becomes circularly polarized light 902C. The circularly polarized light 902C is reflected by aluminum total reflection films 1005, whereafter it passes through the quarter wavelength plate 506 again and thereby becomes P-polarized light whose polarization direction has been rotated by 90°, and passes through polarizing separating film 1004.

The incident natural light can be uniformized into P-polarized light in the manner described above.

Figure 16 shows a fourteenth embodiment of the present invention.

The difference of this embodiment from the embodiment of Figure 13 is that in the embodiment of Figure 13, the half wavelength plates are intermittently provided, whereas in this embodiment, a quarter wavelength plate is provided on substantially the whole of that surface of the plane parallel plate 903 which is adjacent to the condensing lens 1301. In the other points, the present embodiment is similar to the embodiment of

Figure 13.

Of the light beam 902 having had its beam width compressed by the condensing lens 1301, P-polarized light 902P is transmitted through polarizing separating film 1304 provided on that surface of the plane parallel plate 903 which is opposite to the condensing lens 1301 and S-polarized light 902S is reflected by the polarizing separating film 1304. the S-polarized light 902S passes through a quarter wavelength plate 606 provided on that surface of the plane parallel plate 903 which is adjacent to the condensing lens 1301, whereby it becomes circularly polarized light. The circularly polarized light is reflected by aluminum total reflection films 1305, whereafter it passes through the quarter wavelength plate 606 again, whereby it becomes P-polarized light whose polarization direction has been rotated by 90°, and passes through the polarizing separating film 1304.

The incident natural light can be uniformized into P-polarized light in the manner described above.

In the embodiments of the Figures 15 and 16, the polarizing separating film and the quarter wavelength plate are provided on substantially the whole surface of the plane parallel plate and therefore, masking is not necessary when they are formed and thus, the manufacturing process can be

simplified. Also, as compared with the aluminum reflection film, the polarizing separating film and the wavelength plate are great in the deterioration of performance in their end portions and therefore, the construction in which the polarizing separating film and the wavelength plate need not be intermittently provided is more preferable from the viewpoint of maintaining the performance of the polarizing element.

In the above-described embodiments, a half wavelength plate or a quarter wavelength plate has been described as being used as polarizing rotational means, but besides these, use may be made of resin film, an optically active substance such as a liquid crystal plate, or a polarization plane rotating device such as a Faraday cell to rotate the polarization direction. Also, the illuminating system has been described as a condensing lens comprised of cylindrical minute lenses, but the illuminating system may be one provided with a light source portion comprising a number of light emitting elements arranged side by side, and a fly-eye lens for averaging the light emitted by the light source portion or dividing said light into a plurality of lights.

Although the optical surface of each of the cylindrical minute lenses constituting the condensing

lens has not been specifically described, said surface can be made into an aspherical surface to thereby enhance the light condensing performance and greatly decrease the loss of the quantity of light and the occurrence of flare light.

As for the light condensing member, it may be comprised of a prism. Also, the light condensing member may be a lens to be rotated and a plurality of such members may be arranged in a checkered pattern. In such case, those of the total reflection mirror, the polarizing separating film and the polarizing rotational means (such as the half wavelength plate) which are discretely arranged can be arranged in conformity with the arrangement of the light condensing members.

The projectors using the polarizing units shown in Figures 2 and 4 - 16 are endowed with the above-described effects.

The present invention is constructed as described above and therefore achieves the following effects:

1. It has the effect of utilizing the incident light efficiently and brightening the image projected by the projector.

2. The polarized state can be uniformized by a simple construction in which polarizing separating film, total reflection film and an element

(film) creating a polarizing rotating action are provided on a plane parallel plate.

3. The polarizing conversion unit can be made compact and light in weight, whereby the projector can be made compact.

WHAT IS CLAIMED IS:

1. A polarizing element for dividing light into first and second polarized lights differing in polarized state from each other by a polarizing dividing surface, directing said first polarized light in a first direction, reflecting said second polarized light by a reflecting surface and directing it in said first direction, and varying the polarized state of at least one of said first and second polarized lights, to thereby make the polarized states of said first and second polarized lights coincident with each other, characterized in that said polarizing dividing surface is disposed on one surface of a plane parallel plate and said reflecting surface is disposed on the other surface of the plane parallel plate, and said light enters obliquely from said one surface or said other surface.

2. A polarizing element according to Claim 1, wherein half wavelength optical phase film is formed at a predetermined location on said one surface of said plane parallel plate to vary the polarized state of at least one of said first and second polarized lights to thereby make the polarized states of said two polarized lights coincident with each other.

3. A polarizing element according to Claim 1, wherein a half wavelength optical phase plate is disposed in the optical path of at least one of said first and second polarized lights to vary the polarized state of at least one of said first and second polarized lights to thereby make the polarized states of said two polarized lights coincident with each other.

4. A polarizing element according to Claim 1, wherein a half wavelength optical phase plate is formed at a predetermined location on said one surface or said other surface of said plane parallel plate to vary the polarized state of at least one of said first and second polarized lights to thereby make the polarized states of said two polarized lights coincident with each other.

5. A polarizing conversion unit having:

an illuminating system for supplying a lattice-like light pattern; and

a polarizing element for converting said lattice-like light pattern into substantially dense polarized light;

said polarizing element having a polarizing dividing surface disposed on one surface of a plane parallel plate and a reflecting surface disposed on

the other surface of the plane parallel plate, said lattice-like light pattern from said illuminating system entering obliquely from said one surface or said other surface, partial lights forming said lattice-like light being divided into first and second polarized lights differing in polarized state from each other by said polarizing dividing surface, said first polarized light being directed in a first direction, said second polarized light being reflected by said reflecting surface and directed in said first direction, the polarized state of at least one of said first and second polarized lights being varied to thereby make the polarized states of said first and second polarized lights coincident with each other.

6. A polarizing conversion unit according to Claim 5, wherein said illuminating system is provided with a light source portion comprising a number of light emitting elements arranged side by side, and cylindrical lenses corresponding to said light emitting elements.

7. A polarizing conversion unit according to Claim 5, wherein said illuminating system is provided with a light source portion comprising a number of light emitting elements arranged side by side, and fly-eye lenses corresponding to said light

emitting elements.

8. A polarizing conversion unit according to Claim 5, wherein said illuminating system is provided with a single light source portion, and a cylindrical lens for dividing the light from said light source portion into a plurality of partial lights.

9. A polarizing conversion unit according to Claim 5, wherein said illuminating system is provided with a single light source portion, and a fly-eye lens for dividing the light from said light source portion into a plurality of partial lights.

10. A polarizing conversion unit according to Claim 5, wherein a half wavelength optical phase plate is disposed in the optical path of at least one of said first and second polarized lights to vary the polarized state of at least one of said first and second polarized lights to thereby make the polarized states of said two polarized lights coincident with each other.

11. A polarizing conversion unit according to Claim 10, wherein said half wavelength optical

phase plate is formed at a predetermined location on said one surface of said plane parallel plate.

12. A polarizing conversion unit according to Claim 11, wherein said polarizing dividing surface and said half wavelength optical phase plate are alternately formed correspondingly to said lattice-like light pattern, and the lattice-like light from said illuminating system enters from said polarizing dividing surface on said one surface.

13. A polarizing conversion unit according to Claim 5, wherein a quarter wavelength optical phase plate is formed at a predetermined location on said one surface or said other surface of said plane parallel plate to vary the polarized state of at least one of said first and second polarized lights to thereby make the polarized states of said two polarized lights coincident with each other.

14. A polarizing conversion unit according to Claim 13, wherein said quarter wavelength optical phase plate is formed on substantially the whole of said one surface or said other surface of said plane parallel plate.

15. A polarizing conversion unit according

to Claim 13, wherein said quarter wavelength optical phase plate is formed on substantially the whole of said one surface or said other surface of said plane parallel plate, said reflecting surface is further formed on substantially the whole of said other surface, and the light from said illuminating system enters from said one surface.

16. A polarizing conversion unit according to Claim 5, wherein said reflecting surface is formed on substantially the whole of said other surface of said plane parallel plate.

17. A polarizing conversion unit according to Claim 5, wherein said polarizing dividing surface is formed on substantially the whole of said one surface of said plane parallel plate.

18. A polarizing conversion unit according to Claim 17, wherein a half wavelength optical phase plate is provided on the polarizing dividing surface formed on substantially the whole of said one surface, correspondingly to said lattice-like light, to vary the polarized state of at least one of said first and second polarized lights to thereby make the polarized states of said two polarized lights coincident with each other, and the light from

said illuminating system enters from said one surface.

19. A polarizing conversion unit according to Claim 18, wherein said reflecting surface is formed on substantially the whole of said other surface of said plane parallel plate.

20. A polarizing conversion unit according to Claim 5, wherein said polarizing dividing surface is disposed on one surface of said plane parallel plate, and the lattice-like light from said illuminating system enters from said one surface or said other surface.

21. A projector having:

an illuminating system for supplying a lattice-like light pattern;

a polarizing element for converting said lattice-like light pattern into substantially dense polarized light;

said polarizing element having a polarizing dividing surface disposed on one surface of a plane parallel plate and a reflecting surface disposed on the other surface of the plane parallel plate, the lattice-like light pattern from said illuminating system entering obliquely from said one surface or

said other surface, partial lights forming said lattice-like light pattern being divided into first and second polarized lights differing in polarized state from each other by said polarizing dividing surface, said first polarized light being directed in a first direction, said second polarized light being reflected by said reflecting surface and directed in said first direction, the polarized state of at least one of said first and second polarized lights being varied to thereby make the polarized states of said first and second polarized lights coincident with each other;

an image generator for modulating said dense polarized light in conformity with a video signal to thereby generate image light; and

a projecting optical system for projecting said image light.

22. A projector having:

a light source for supplying light;

color resolving means for resolving said light into red, green and blue lights;

means for converting each of said red, green and blue lights into a lattice-like light pattern, said means being disposed in the optical paths of said red, green and blue lights;

a polarizing element disposed in the optical

paths of each of said red, green and blue lights for converting each said lattice-like light pattern into substantially dense polarized light;

said polarizing element having a polarizing dividing surface disposed on one surface of a plane parallel plate and a reflecting surface disposed on the other surface of the plane parallel plate, said lattice-like light pattern entering obliquely from said one surface or said other surface, partial lights forming said lattice-like light pattern being divided into first and second polarized lights differing in polarized state from each other by said polarizing dividing surface, said first polarized light being directed in a first direction, said second polarized light being reflected by said reflecting surface and directed in said first direction, the polarized state of at least one of said first and second polarized lights being varied to thereby make the polarized states of said first and second polarized lights coincident with each other;

an image generator for modulating said dense polarized light in conformity with a video signal to thereby generate image light, said generator being disposed in the optical path of each of said red, green and blue lights and generating each of red, green and blue image lights; and

a projecting optical system for projecting said image light.

23. A projector having:

a light source for supplying light;

color resolving means for resolving said light into red, green and blue lights;

means for converting each of said red, green and blue lights into a lattice-like light pattern, said means being disposed in the common optical path of two of said red, green and blue lights and the optical path of the other color light;

a polarizing element disposed near said converting means for converting each of said lattice-like light patterns into substantially dense polarized light;

said polarizing element having a polarizing dividing surface disposed on one surface of a plane parallel plate and a reflecting surface disposed on the other surface of the plane parallel plate, said lattice-like light pattern entering obliquely from said one surface or said other surface, partial lights forming said lattice-like light pattern being divided into first and second polarized lights differing in polarized state from each other by said polarizing dividing surface, said first polarized light being directed in a first direction, said

second polarized light being reflected by said reflecting surface and directed in said first direction, the polarized state of at least one of said first and second polarized lights being varied to thereby make the polarized states of said first and second polarized lights coincident with each other;

an image generator for modulating said dense polarized light in conformity with a video signal to thereby generate image light, said generator being disposed in the optical path of each of said red, green and blue lights and generating each of red, green and blue image lights; and

a projecting optical system for projecting said image light.

24. A polarizing element for dividing light into reflected light and transmitted light differing in polarization direction from each other by a polarizing dividing surface, reflecting said reflected light by a reflecting surface and directing it in a direction substantially parallel to said transmitted light, and varying the polarization direction of said reflected light to thereby make it coincident with the polarization direction of said transmitted light, characterized in that said

polarizing dividing surface is provided on substantially the whole of one surface of a plane parallel plate, said reflecting surface is intermittently provided on the other surface of the plane parallel plate, and said light enters obliquely from said other surface.

25. A polarizing element according to Claim 24, wherein a quarter wavelength optical phase plate is provided on substantially the whole surface between said one surface of said plane parallel plate and said polarizing dividing surface to vary the polarization direction of said reflected light to thereby make it coincident with the polarization direction of said transmitted light.

26. A polarizing element according to Claim 24, wherein an optically active substance is provided on substantially the whole surface between said one surface of said plane parallel plate and said polarizing dividing surface to vary the polarization direction of said reflected light to thereby make it coincident with the polarization direction of said transmitted light.

27. A polarizing element according to Claim 24, wherein a quarter wavelength optical phase plate

is provided on substantially the whole of said other surface of said plane parallel plate and between said plane parallel plate and said reflecting surface to vary the polarization direction of said reflected light to thereby make it coincident with the polarization direction of said transmitted light.

28. A polarizing element according to Claim 24, wherein an optically active substance is provided on substantially the whole of said other surface of said plane parallel plate and between said plane parallel plate and said reflecting surface to vary the polarization direction of said reflected light to thereby make it coincident with the polarization direction of said transmitted light.

29. A polarizing element according to Claim 24, wherein said plane parallel plate is formed of an optically active substance to vary the polarization direction of said reflected light to thereby make it coincident with the polarization direction of said transmitted light.

30. A polarizing conversion unit having:

an illuminating system for supplying a lattice-like light pattern; and

a polarizing element for converting said

lattice-like light pattern into substantially dense polarized light;

said polarizing element having a polarizing dividing surface provided on substantially the whole of one surface of a plane parallel plate and a reflecting surface intermittently provided on the other surface of the plane parallel plate, the lattice-like light pattern from said illuminating system entering obliquely from said other surface, partial lights forming said lattice-like light pattern being divided into reflected light and transmitted light differing in polarization direction from each other by said polarizing dividing surface, said reflected light being reflected by said reflecting surface and directed in a direction substantially parallel to said transmitted light, the polarization direction of said reflected light being varied to thereby make it coincident with the polarization direction of said transmitted light.

31. A polarizing conversion unit according to Claim 30, wherein said illuminating system is provided with a light source portion comprising a number of light emitting elements arranged side by side, and cylindrical lenses corresponding to said light emitting elements.

32. A polarizing conversion unit according to Claim 30, wherein said illuminating system is provided with a single light source portion, and a cylindrical lens for dividing the light from said light source portion into a plurality of partial lights.

33. A projector having:

an illuminating system for supplying a lattice-like light pattern;

a polarizing element for converting said lattice-like light pattern into substantially dense polarized light;

said polarizing element having a polarizing dividing surface provided on substantially the whole of one surface of a plane parallel plate and a reflecting surface intermittently provided on the other surface of the plane parallel plate, the lattice-like light pattern from said illuminating system entering obliquely from said other surface, partial lights forming said lattice-like light pattern being divided into reflected light and transmitted light differing in polarization direction from each other by said polarizing dividing surface, said reflected light being reflected by said reflecting surface and directed in a direction substantially parallel to said transmitted light,

the polarization direction of said reflected light being varied to thereby make it coincident with the polarization direction of said transmitted light;

an image generator for modulating said dense polarized light in conformity with a video signal to thereby generate image light; and

a projecting optical system for projecting said image light.

34. A projector having:

a light source for supplying light;

color resolving means for resolving said light into red, green and blue lights;

means for converting each of said red, green and blue lights into a lattice-like light pattern, said means being disposed in the light path of each of said red, green and blue lights;

a polarizing element disposed in the optical path of each of said red, green and blue lights for converting each of said lattice-like patterns into substantially dense polarized light;

said polarizing element having a polarizing dividing surface provided on substantially the whole of one surface of a plane parallel plate and a reflecting surface intermittently provided on the other surface of the plane parallel plate, the lattice-like light pattern from said illuminating

system entering obliquely from said other surface, partial lights forming said lattice-like light pattern being divided into reflected light and transmitted light differing in polarization direction from each other by said polarizing dividing surface, said reflected light being reflected by said reflecting surface and directed in a direction substantially parallel to said transmitted light, the polarization direction of said reflected light being varied to thereby make it coincident with the polarization direction of said transmitted light;

an image generator for modulating said dense polarized light in conformity with a video signal to thereby generate image light, said generator being disposed in the optical path of each of said red, green and blue lights and generating each of red, green and blue image lights; and

a projecting optical system for projecting said image light.

35. A projector having:

a light source for supplying light;

color resolving means for resolving said light into red, green and blue lights;

means for converting each of said red, green and blue lights into a lattice-like light pattern, said means being disposed in the common

optical path of two of said red, green and blue lights and the optical path of the other color light;

a polarizing element disposed near said converting means for converting each of said lattice-like light patterns into substantially dense polarized light;

said polarizing element having a polarizing dividing surface provided on substantially the whole of one surface of a plane parallel plate and a reflecting surface intermittently provided on the other surface of the plane parallel plate, the lattice-like light pattern from said illuminating system entering obliquely from said other surface, partial lights forming said lattice-like light pattern being divided into reflected light and transmitted light differing in polarization direction from each other by said polarizing dividing surface, said reflected light being reflected by said reflecting surface and directed in a direction substantially parallel to said transmitted light, the polarization direction of said reflected light being varied to thereby make it coincident with the polarization direction of said transmitted light;

an image generator for modulating said dense polarized light in conformity with a video signal to thereby generator image light, said generator being disposed in the optical path of each of said red,

green and blue lights and generating each of red, green and blue image lights; and

a projecting optical system for projecting said image light.

ABSTRACT OF THE DISCLOSURE

This specification discloses a polarizing element for dividing light into first and second polarized lights differing in polarized state from each other by a polarizing dividing surface, directing the first polarized light in a first direction, reflecting the second polarized light by a reflecting surface and directing it in the first direction, and varying the polarized state of at least one of the first and second polarized lights to thereby make the polarized states of the first and second polarized lights coincident with each other, characterized in that the polarizing dividing surface is disposed on one surface of a plane parallel plate and the reflecting surface is disposed on the other surface of the plane parallel plate, and the light enters obliquely from the one surface or the other surface. The specification also discloses a polarizing conversion unit provided with such polarizing element, and a projector provided with such polarizing conversion unit.

PATENT

Docket No. 1232-4046

# COMBINED DECLARATION AND POWER OF ATTORNEY FOR ORIGINAL, DESIGN, NATIONAL STAGE OF PCT, SUPPLEMENTAL, DIVISIONAL, CONTINUATION OR CONTINUATION-IN-PART APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:
A PLATE-LIKE POLARIZING ELEMENT, A POLARIZING CONVERSION UNIT PROVIDED WITH THE ELEMENT, AND A PROJECTOR PROVIDED WITH THE UNIT
the specification of which

a. [x] is attached hereto

b. [ ] was filed on _____ as application Serial No. _____ and was amended on _____. (if applicable).

PCT FILED APPLICATION ENTERING NATIONAL STAGE

c. [ ] was described and claimed in International Application No. _____ filed on _____ and as amended on _____. (if any).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a).

[x] I hereby claim foreign priority benefits under Title 35, United States Code § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

[ ] The attached 35 U.S.C. § 119 claim for priority for the U.S. application(s) listed below forms a part of this declaration.

| Country | Application Number | Date of filing (day, month, yr) | Date of issue (day, month, yr) | Priority Claimed |
|---|---|---|---|---|
| JAPAN | 3-103317 | 9 April 1991 | | [x] YES [ ] NO |
| | | | | [ ] YES [ ] NO |
| | | | | [ ] YES [ ] NO |

Express Mail No. GB301072959

PATENT

Docket No. 1232-4046

ADDITIONAL STATEMENTS FOR
DIVISIONAL, CONTINUATION OR CONTINUATION-IN-PART

I hereby claim the benefit under Title 35, United States Code § 120 of any United States application(s) listed below.

NONE

| Application Serial No. | Filing Date | Status (patented, pending, abandoned) |
|---|---|---|
| | | |

| Application Serial No. | Filing Date | Status (patented, pending, abandoned) |
|---|---|---|
| | | |

[ ] In this continuation-in-part application, insofar as the subject matter of any of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I hereby appoint the following attorneys and/or agents with full power of substitution and revocation, to prosecute this application, to receive the patent, and to transact all business in the Patent and Trademark Office connected therewith: Jerome G. Lee (Reg. No. 16,967), John D. Foley (Reg. No. 16,836), John A. Diaz (Reg. No. 19,550), Thomas P. Dowling (Reg. No. 19,221), John C. Vassil (Reg. No. 19,098), Warren H. Rotert (Reg. No. 19,659), Alfred P. Ewert (Reg. No. 19,887), David H. Pfeffer, P.C. (Reg. No. 19,825), Harry C. Marcus (Reg. No. 22,390), Robert E. Paulson (Reg. No. 21,046), Stephen R. Smith (Reg. No. 22,615), Kurt E. Richter (Reg. No. 24,052), J. Robert Dailey (Reg. No. 27,434), Eugene Moroz (Reg. No. 25,237), John F. Sweeney (Reg. No. 27,471), Arnold I. Rady (Reg. No. 26,601), Christopher A. Hughes (Reg. No. 26,914), William S. Feiler (Reg. No. 26,728), Joseph A. Calvaruso (Reg. No. 28,287), James W. Gould (Reg. No. 28,859), Richard C. Komson (Reg. No. 27,913), Israel Blum (Reg. No. 26,710), Bartholomew Verdirame (Reg. No. 28,483), Maria C. H. Lin (Reg. No. 29,323), Joseph A. DeGirolamo (Reg. No. 28,595), and Christopher E. Chalsen (Reg. No. 30,936) of Morgan & Finnegan whose address is: 345 Park Avenue, New York, New York 10154.

[x] I hereby authorize the U.S. attorneys and/or agents named hereinabove to accept and follow instructions from _____ as to any action to be taken in the U.S. Patent and Trademark Office regarding this application without direct communication between the U.S. attorneys and/or agents and me. In the event of a change in the person(s) from whom instructions may be taken I will so notify the U.S. attorneys and/or agents named hereinabove.

PATENT

Docket No. 1232-4046

I hereby specify the following as the correspondence address to which all communications about this application are to be directed:

SEND CORRESPONDENCE TO: CHRISTOPHER E. CHALSEN

MORGAN & FINNEGAN, 345 Park Avenue, New York, New York 10154

DIRECT TELEPHONE CALLS TO: CHRISTOPHER E. CHALSEN
(212) 758-4800

Full name of sole or first inventor NOZOMU KITAGISHI

Inventor's signature* Nozomu Kitagishi

Residence Hachioji-shi, Tokyo, Japan date April 2, 1992

Citizenship JAPAN

Post Office Address c/o Canon Kabushiki Kaisha
30-2, 3-chome, Shimomaruko, Ohta-ku, Tokyo, Japan

Full name of second joint inventor, if any _____

Inventor's signature* _____

Residence _____ date

Citizenship _____

Post Office Address _____

[ ] ATTACHED IS ADDED PAGE TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR SIGNATURE BY THIRD AND SUBSEQUENT INVENTORS FORM.

* Before signing this declaration, each person signing must:

1. Review the declaration and verify the correctness of all information therein; and

2. Review the specification and the claims, including any amendments made to the claims.

After the declaration is signed, the specification and claims are not to be altered.

To the inventor(s):
The following are cited in or pertinent to the declaration attached to the accompanying application:

Title 37, Code of Federal Regulation, §1.56

Duty of disclosure....

(a) A duty of candor and good faith toward the Patent and Trademark Office rests on the inventor, on each attorney or agent who prepares or prosecutes the application and on every other individual who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application. All such individuals have a duty to disclose to the Office information they are aware of which is material to the examination of the application. Such information is material where there is a substantial likelihood that a reasonable examiner would consider it important in deciding whether to allow the application to issue as a patent. The duty is commensurate with the degree of involvement in the preparation or prosecution of the application.

* * * *

c) Any application may be stricken from the files if:

(1) An oath or declaration ... is signed in blank;

(2) An oath or declaration ... is signed without review thereof by the person making the oath or declaration;

(3) an oath or declaration ... is signed without review of the specification, including the claims ...;

or

(4) The application papers filed in the Office are altered after the signing of an oath or declaration ... referring to those application papers.

Title 35, U.S. Code, § 119

Benefit of earlier filing date in foreign country; right of priority

An application for patent for an inventor filed in this country by any person who has, or whose legal representatives or assigns have, previously regularly filed an application for a patent for the same inventor in a foreign country which affords similar privileges in the case of applications filed in the United States or to citizens of the United States, shall have the same effect as the same application would have if filed in this country on the date on which the application for patent for the same invention was first filed in such foreign country, if the application in this country is filed within twelve months from the earliest date on which such foreign application was filed; but no patent shall be granted on any application for patent for an invention which had been patented or described in a printed publication in any country more than one year before the date of the actual filing of the application in this country, or which had been in public use or on sale in this country more than one year prior to such filing.

Title 35, U.S. Code, § 102

Benefit or earlier filing date in the United States

An application for patent for an invention disclosed in the manner provided by the first paragraph of section 112 of this title in an application previously filed in the United States, or as provided by section 363 of this title, which is filed by an inventor or inventors named in the previously filed application shall have the same effect, as to such invention, as though filed on the date of the prior application, if filed before the patenting or abandonment of or termination of proceedings on the first application or an application similarly entitled to the benefit of the filing date of the first application and if it contains or is amended to contain a specific reference to the earlier filed application.

Title 35, U.S. Code § 101

Inventions patentable

Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

Title 35 U.S. Code § 102

Conditions for patentability; novelty and loss of right to patent

A person shall be entitled to a patent unless –

(a) the invention was known or used by others in this country, or patented or described in a printed publication in this country, more than one year prior to the date of the application for patent in the United States, or

(b) the invention was patented or described in a printed publication in this or foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States, or

(c) he has abandoned the inventor, or

(d) the invention was first patented or caused to be patented, or was the subject of an inventor's certificate, by the applicant or his legal representatives or
assigns in a foreign country prior to the date of the application for patent in this country on an application for patent or inventor's certificate filed more than twelve months before the filing of the application in the United States, or

* * * *

(e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371(c) of this title before the invention thereof by the applicant for patent, or

(f) he did not himself invent the subject matter sought to be patented, or

(g) before the applicant's invention thereof the invention was made in this country by another who had not abandoned, suppressed, or concealed it. In determining priority of invention there shall be considered not only the respective dates of conception and reduction to practice of the invention, but also the reasonable diligence of one who was first to conceive and last to reduce to practice, from a time prior to conception by the other ...

Title 35, U.S. Code § 103

Conditions for patentability; non-obvious subject matter

A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Subject matter developed by another person, which qualifies as prior art only under subsection (f) or (g) of section 102 of this title, shall not preclude patentability under this section where the subject matter and the claimed invention were, at the time the invention was made, owned by the same person or subject to an obligation of assignment to the same person.

Title 35, U.S. Code § 112 (in part)

Specification

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise and exact terms as to enable any person skilled in the art to which *it* pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

Please read carefully before signing the Declaration attached to the accompanying Application.

If you have any questions, please contact Morgan & Finnegan

Rev. 2/91 M&F

FIG. 1
PRIOR. ART

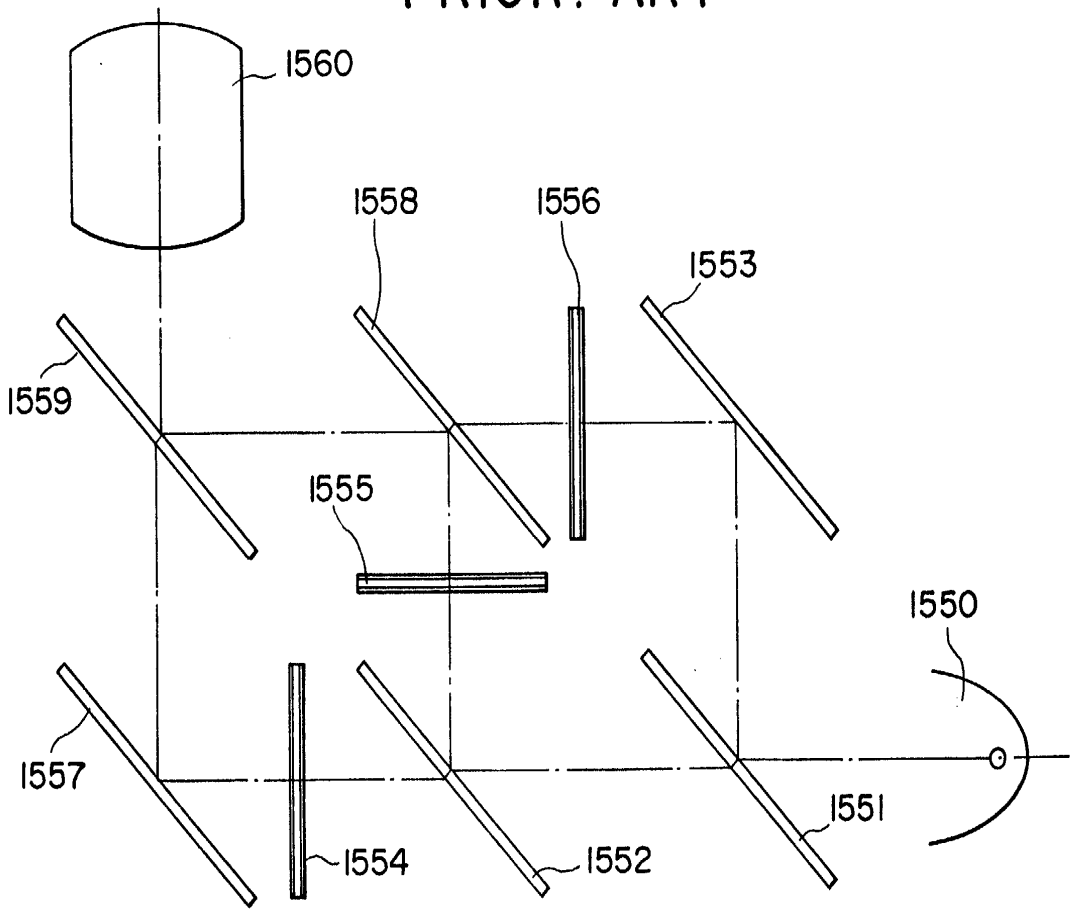


FIG. 2

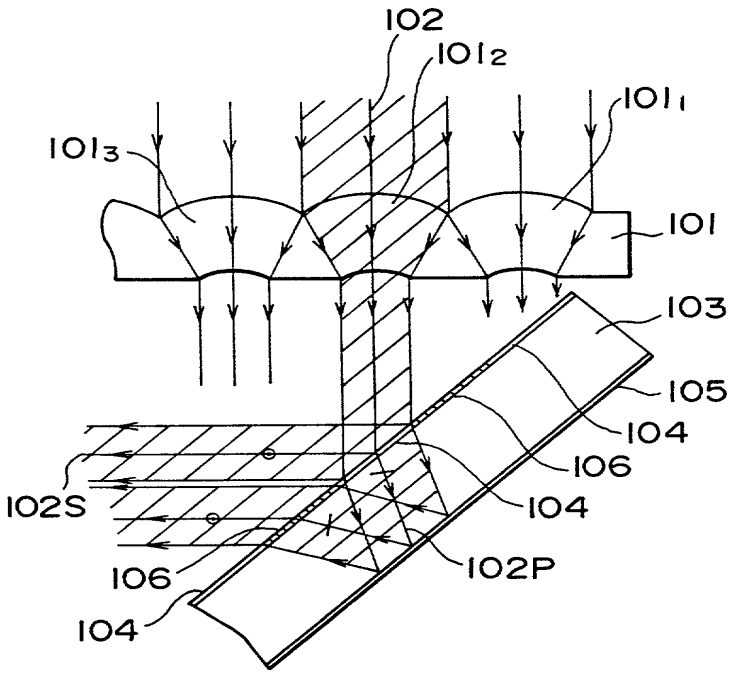


FIG. 3

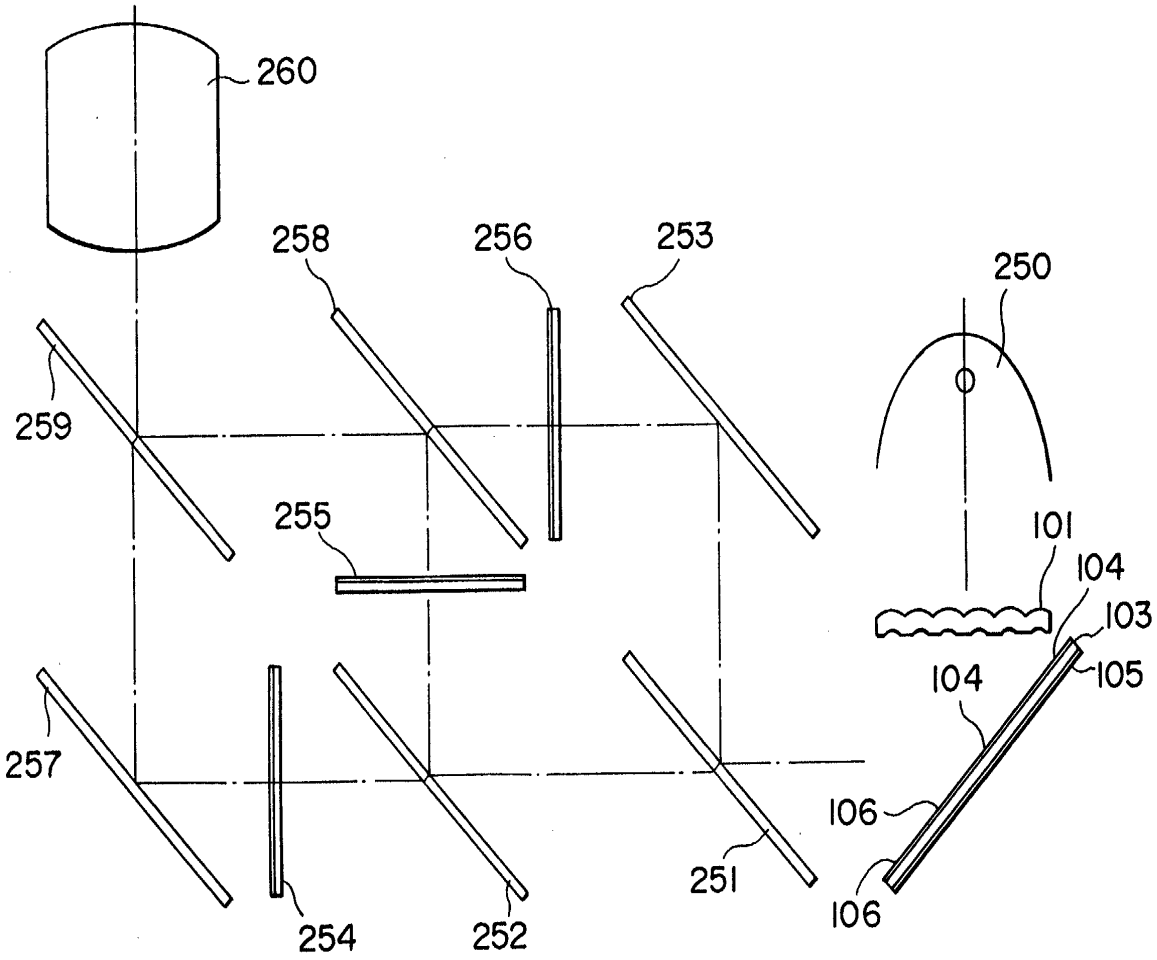


FIG. 4

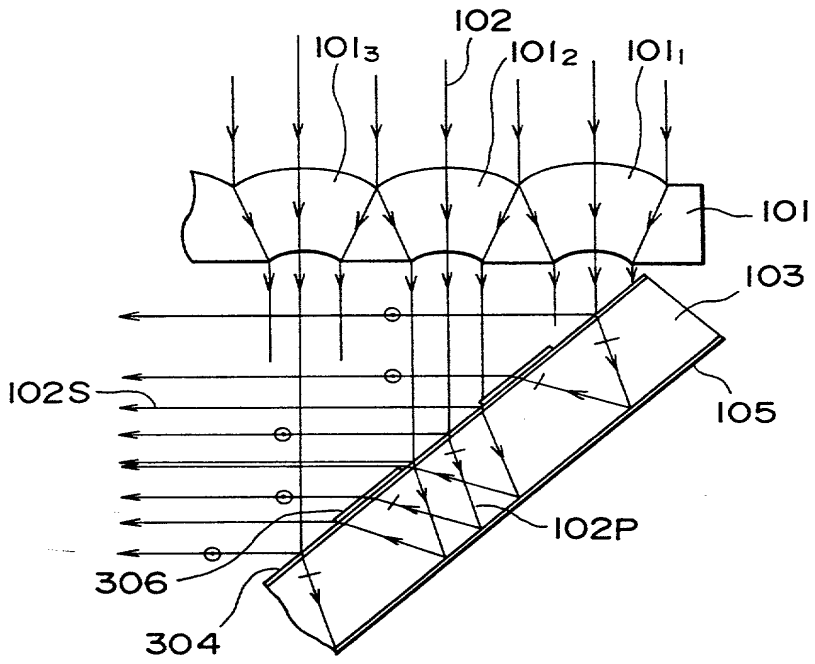


FIG. 5

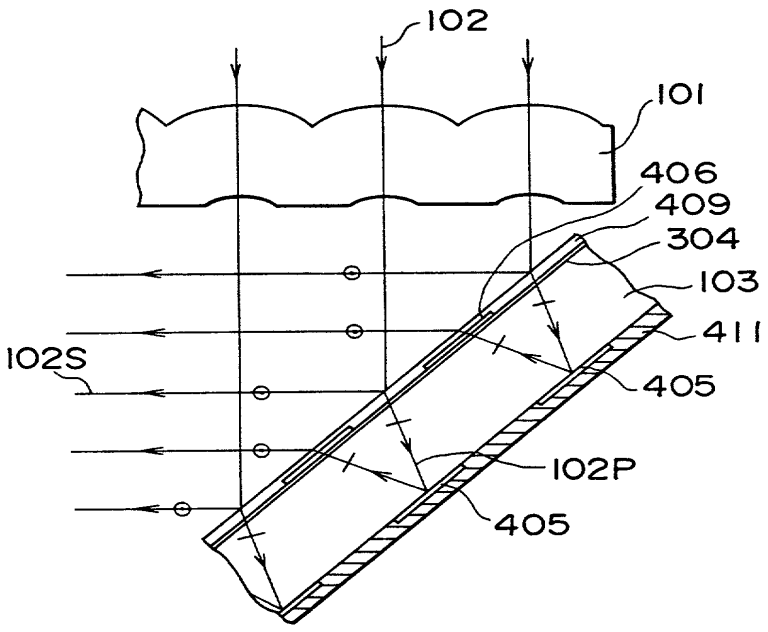


FIG. 6

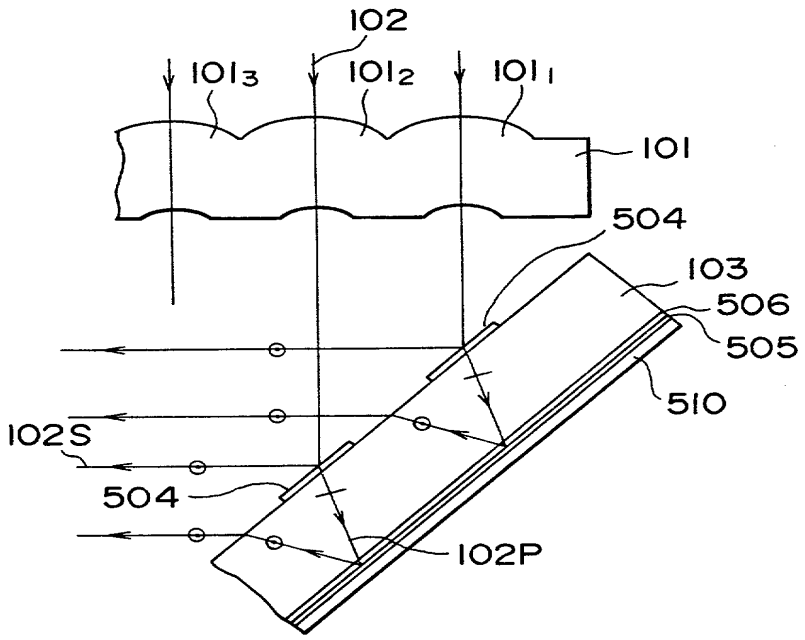


FIG . 7

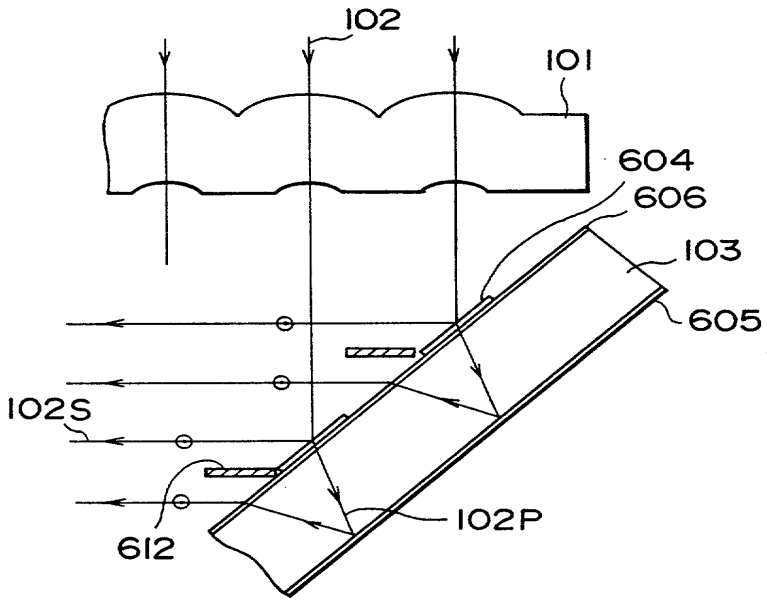


FIG. 8

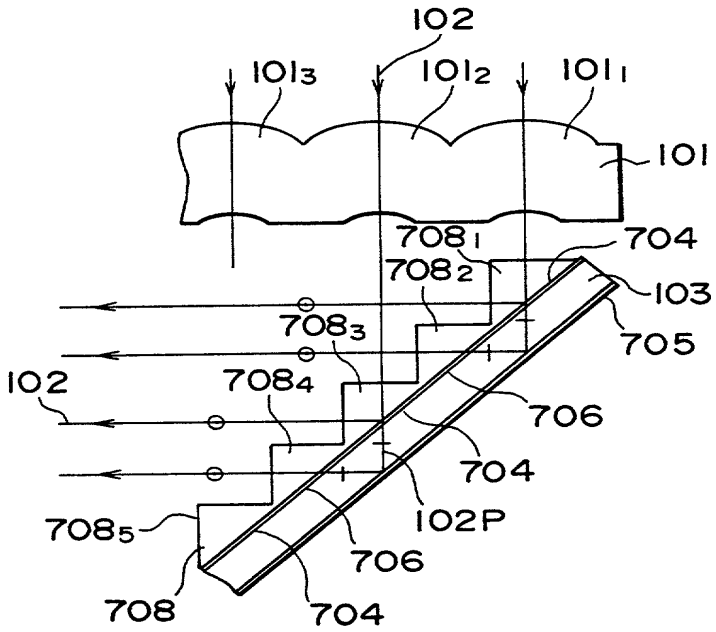

102
$101_3$
$101_2$
$101_1$
101
$708_1$
704
$708_2$
103
$708_3$
705
102
$708_4$
706
704
$708_5$
102P
706
708
704

FIG. 9

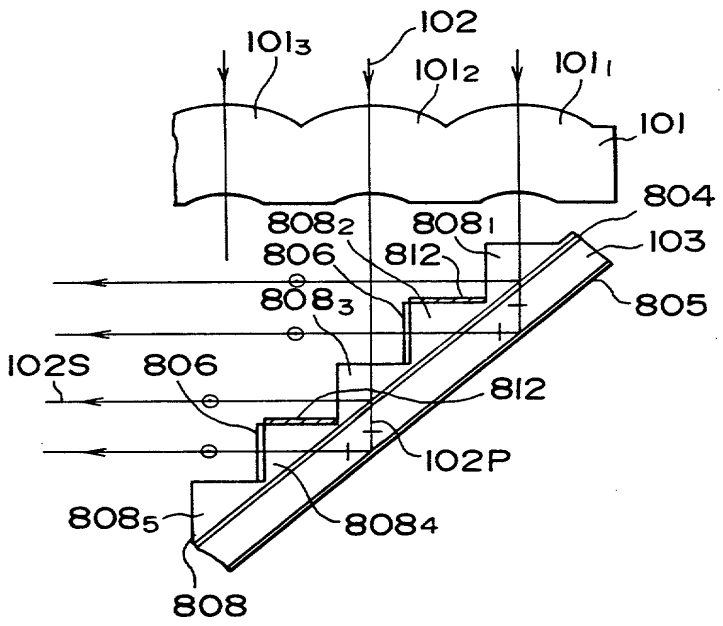

$101_3$
102
$101_2$
$101_1$
101
804
$808_2$
$808_1$
806
812
103
$808_3$
805
102S
806
812
102P
$808_5$
$808_4$
808

FIG. 10

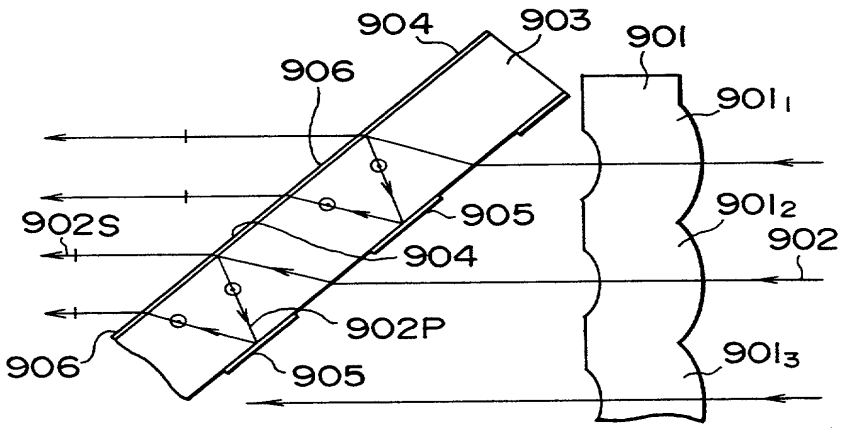

904
903
901
906
$901_1$
$901_2$
902S
905
902
904
902P
906
905
$901_3$

FIG. 11

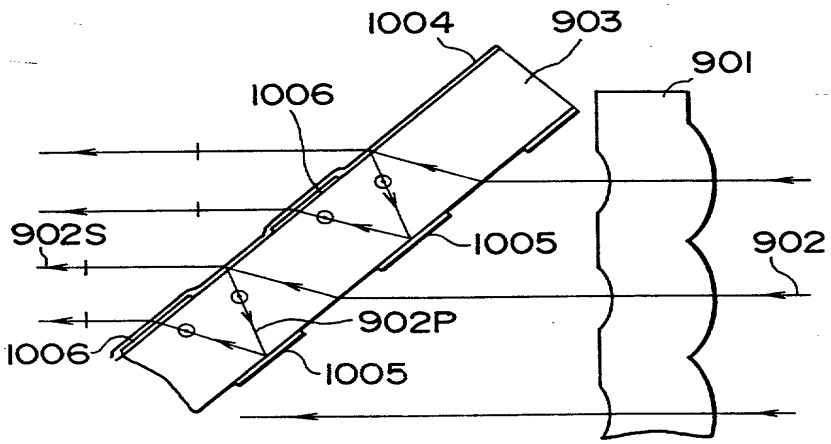

1004
903
901
1006
902S
1005
902
902P
1006
1005

FIG. 12

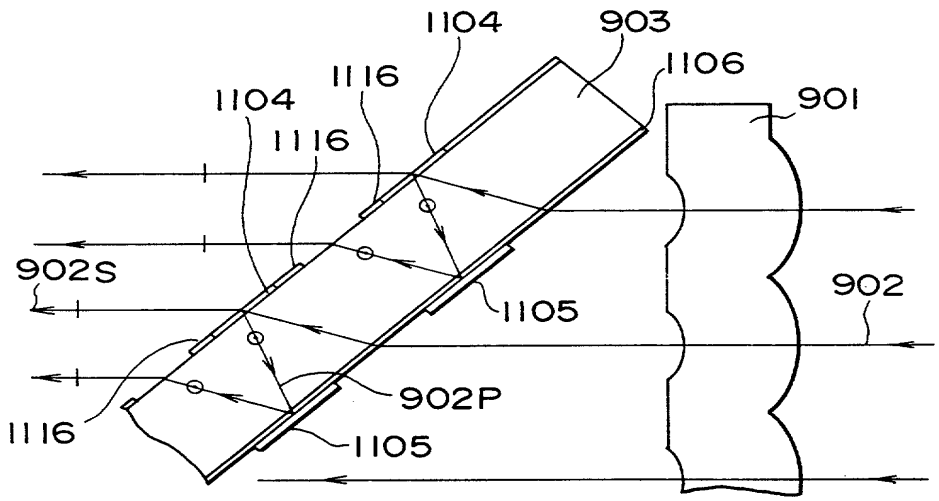


FIG. 13

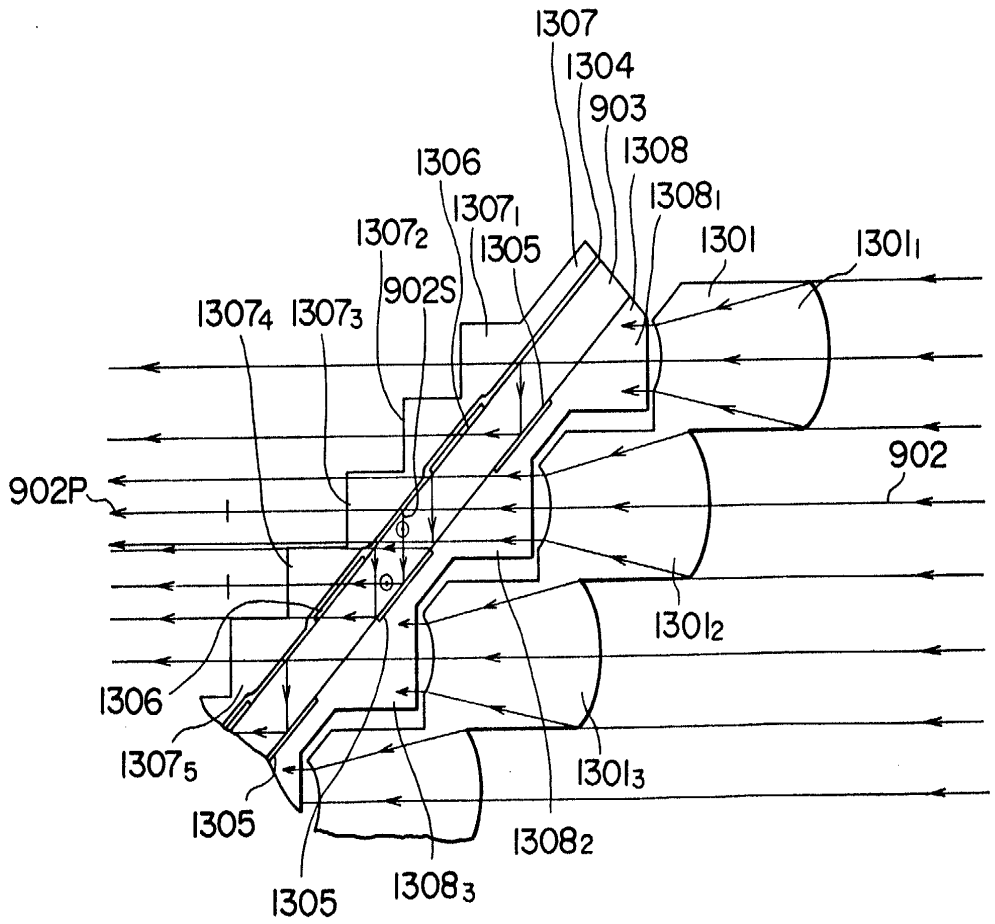


FIG. 14

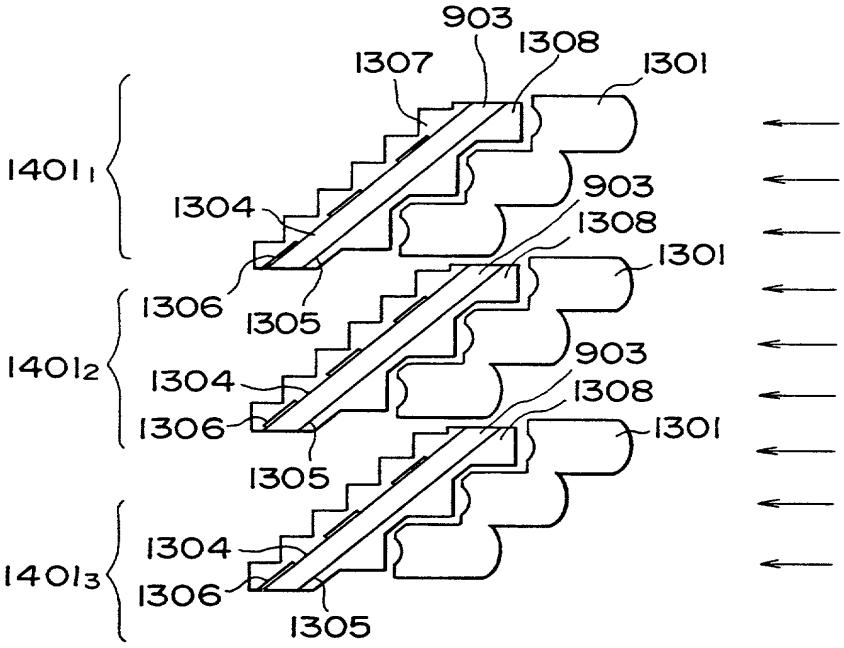

903
1308
1307
1301
1401₁
1304
903
1308
1301
1306
1305
1401₂
903
1304
1308
1306
1301
1305
1304
1401₃
1306
1305

FIG. 15

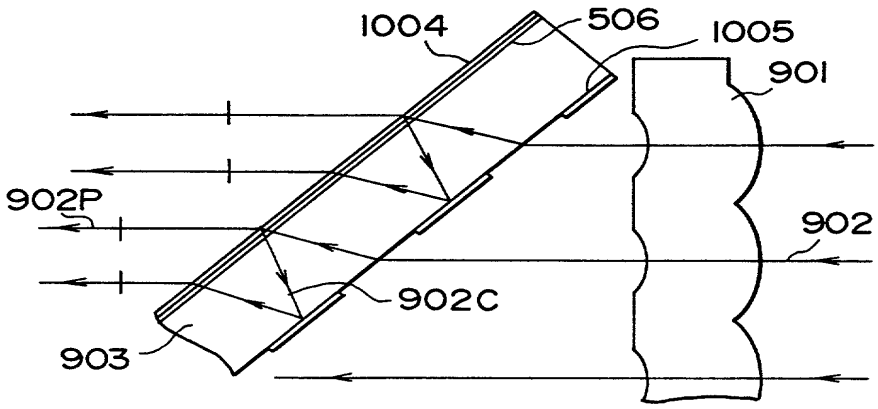
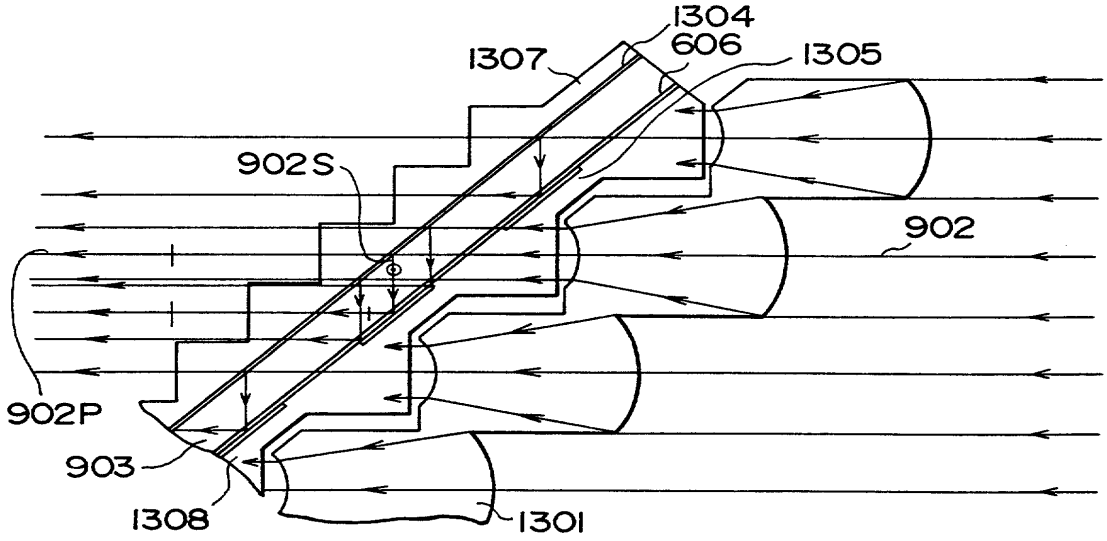

1004
506
1005
901
902P
902
902C
903

FIG. 16


1304
606
1307
1305
902S
902
902P
903
1308
1301